USE OF LIGNIN SULFONATE FOR DUST CONTROL ON HAULAGE ROADS IN ARID REGIONS

By John P. Harmon

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John P. Harmon[1/]

CONTENTS

	Page
Summary and introduction	1
Acknowledgments	4
Toxicity	4
Metallurgical effects	4
Application	4
Quantities	8
Soils best suited for lignin sulfonate road-binder treatment	8
Maintenance of roads	9
Conclusions	9

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ILLUSTRATIONS

Fig.		Page
1.	Heavy trucks disseminate high concentrations of dust on untreated roads; vehicles that follow are often delayed because of poor visibility	2
2.	Mine roads could be treated with conventional road-mix material, except for damage by lugged vehicles such as crawler-type equipment	2
3.	If lignin sulfonate is applied to surface of loose road aggregate without thorough mixing and surface should be damaged by lugged vehicles, damage can be repaired easily	3
4.	Closeup of road damage shown in figure 3	3
5.	First step in treating a dirt road is to eliminate potholes and corrugations by blading	5
6.	Loose rock and gravel that will not pass through a 1-inch ring should be bladed off surface of road	5
7.	Before lignin sulfonate is added, aggregate should be a well-graded mixture of coarse and fine material	6
8.	Lignin sulfonate solids (10-25 percent) in water solution is sprayed repeatedly on prepared surface of road	6
9.	Abrasion caused by heavy vehicles on surface of road treated with lignin sulfonate; 1/16-inch crust can be seen at edge of damaged area	10
10.	Truck on untreated section of mine road, part of which has been treated with lignin sulfonate. Note dust cloud	12
11.	Note that dust cloud stopped abruptly when truck seen in figure 10 reached part of road treated with lignin sulfonate	12

TABLES

1.	Lignin sulfonate (approx. specifications)	7
2.	Ideal-soil material	8

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SUMMARY AND INTRODUCTION

Vehicles traveling on untreated dirt and gravel roads at open-pit mines disseminate high concentrations of dust (fig. 1). Excessive dust creates safety hazards by reducing visibility and may endanger the health of the men who breathe it. If the dust contains free silica, it can cause silicosis. In addition, maintenance costs of mechanical equipment are increased if equipment is operated in extremely dusty places.

Dust on haulage roads in hot, arid country can be controlled if the surface of the road is sprinkled frequently and adequately with water. Often, when roads are sprinkled with water to control the dust, hazards are caused through reduced traction and skidding because of the mud that is formed on the surface of the road. Reducing the amount of water used will help to reduce the hazard of skidding.

At one open-pit mine it costs $97,000 a year to control dust on the haulage road with waste water. Another mine uses 25 million gallons of clean river water a year to control haulage-road dust. Each of these mines has 6 to 7 miles of such roads. If the supply of water is limited, any reduction in the amount of water required for this nonproductive operation results in a worthwhile saving.

Dust can be controlled by applying asphalt, blacktop, or road oil, but when roads are subjected frequently to lugged traffic, the surface will be broken (fig. 2). To be completely satisfactory, any dust-control measure for a haulage road that is used under such conditions should provide a surface that can be reconsolidated with a minimum of material and effort, and the road-treating material should not interfere with metallurgical recovery. Road oil cannot be tolerated in more than trace amounts in flotation circuits. Road aggregate that has been treated with lignin sulfonate and broken later (figs. 3 and 4) can be repaired merely by mixing the broken material with more lignin sulfonate solution and repacking the wetted material. (See section on Maintenance of Roads.)

Lignin sulfonate is a chemical byproduct of wood pulping by the sulfite process. More than 100 sulfite pulp mills are in the United States and Canada - from Florida to Alaska and from the east to the west coasts. They produce more than 30 million gallons of waste solution daily, which contains 10 percent of lignin sulfonate solids and sugars in fixed proportions. To economically handle and transport this dilute solution, it is evaporated, usually at or near the mill where it is produced. The concentrate is available in commercial quantities as spray-dried powder or in solution containing 50 percent solids. Lignin sulfonate, as described in this report, is available commercially as a concentrate of spent sulfite liquor from sulfite pulp mills.

When lignin sulfonate is applied properly to dirt and gravel roads, the fine particles in the road aggregate are bound together in such a way as to improve the surface and reduce dust.

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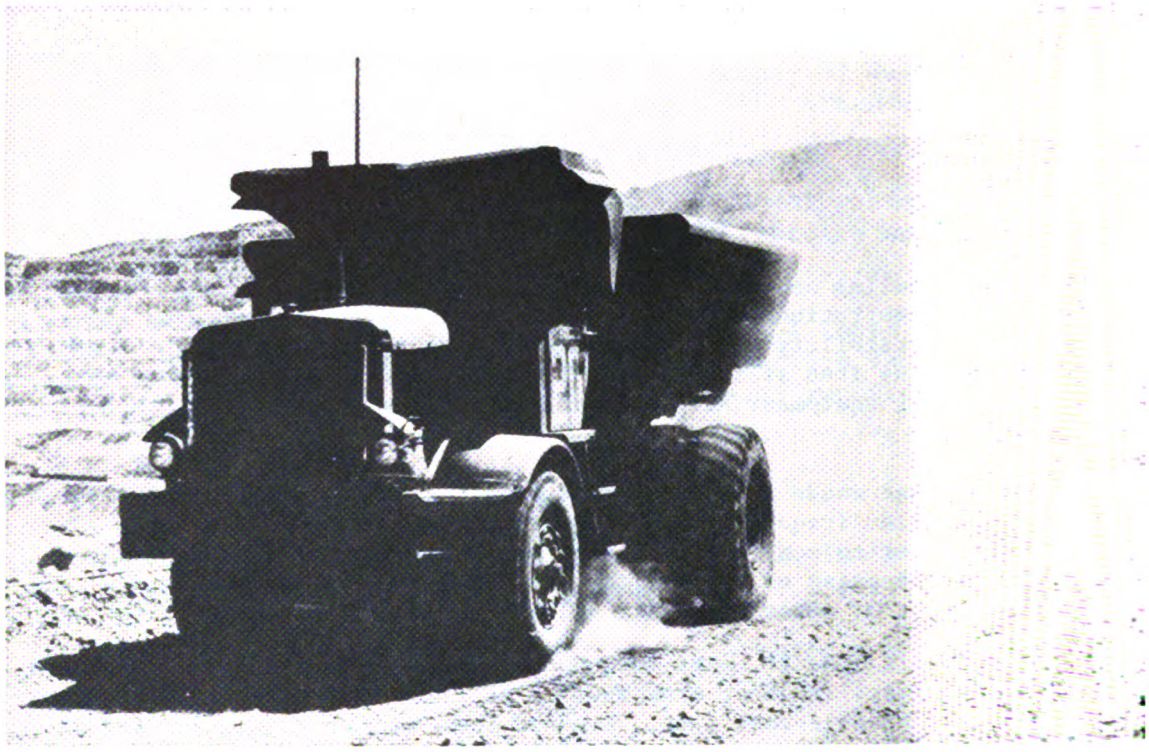

Figure 1. - Heavy trucks disseminate high concentrations of dust on untreated roads; vehicles that follow are often delayed because of poor visibility.

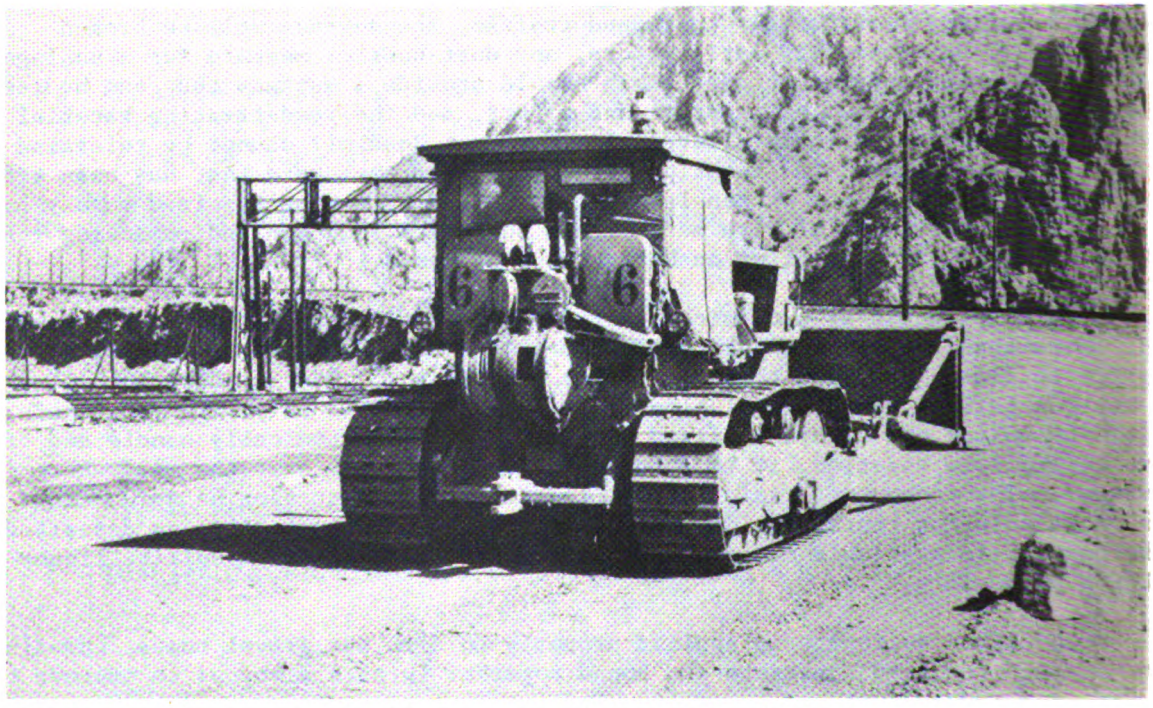

Figure 2. - Mine roads could be treated with conventional road-mix material, except for damage by lugged vehicles such as crawler-type equipment.

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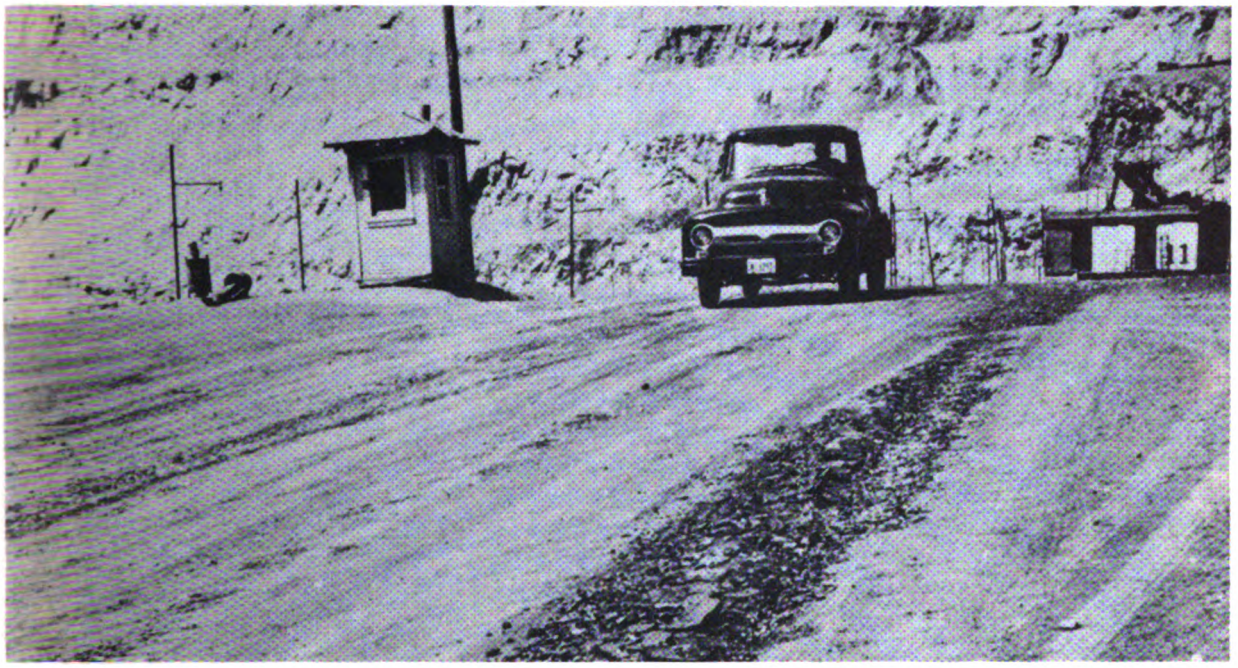

Figure 3. - If lignin sulfonate is applied to surface of loose road aggregate without thorough mixing and surface should be damaged by lugged vehicles, damage can be repaired easily.

Figure 4. - Closeup of road damage shown in figure 3.

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Experience over a decade of use in Wisconsin, 30 or more years in some of the coastal States, and more than 60 years in Sweden has shown that good results can be obtained if lignin sulfonate is mixed properly with road aggregate that contains gravel, sand, and clay.

ACKNOWLEDGMENTS

The author wishes to express his appreciation for technical information on lignin sulfonate supplied to the Bureau of Mines by representatives of Braun Corp., Crown Zellerbach Corp., and Lake States Roadbinder Assoc. The cooperation of mining companies, engineers, and metallurgists at the mines where road tests with lignin sulfonate were conducted is gratefully acknowledged.

TOXICITY

The Bureau of Mines is not aware of results of any complete toxicity tests on lignin sulfonate; however, experience has shown that it has a low order of toxicity. Precautions should be observed to avoid prolonged, intimate exposure to this material. It can be readily washed from the hands, clothing, and equipment with soap and water.

METALLURGICAL EFFECTS

It has been stated that lignin sulfonate may cause undesirable reactions in connection with froth flotation of the ore. If lignin sulfonate is being considered as a means of controlling dust on roads on ore that will be mined, it is suggested that a laboratory test be conducted with the usual pulp and flotation reagents to which lignin sulfonate has been added. The amount of lignin sulfonate used in the test should be about twice as much as would normally be expected to enter the ore. At one mine where lignin sulfonate was reported to have caused a slight decrease in the recovery of sulfide-ore values, it is planned to scarify the surface of any bench treated with lignin sulfonate before that bench is mined. The loosened surfacing material will be removed either to the waste dump or to new road surfaces before the bench of ore is mined. If the surfacing material can be salvaged and reused, a certain saving of road-treating material will be accomplished. If it is not practicable to reuse the surfacing chemical, it will be spread on the waste dump and in this way will be kept out of the mill circuit.

APPLICATION

Best results are obtained if lignin sulfonate is applied to road aggregate according to a few simple rules, which practical roadmen and engineers have developed from experience:2/

1. Scarify and blade the road (fig. 5) to eliminate corrugations and potholes and to loosen the road-surface material to the depth that penetration is desired. All material that will not pass through a 1-inch ring should be bladed to one side (fig. 6). The final aggregate should consist of a good gradation of sizes similar to that shown in figure 7 and table 2. Some roads work easier if a light application of water or lignin sulfonate solution is applied before the first grading to soften the surface of the road.

2/ Lake States Roadbinder Assoc., Sulphite Roadbinder, 28 pp.; Crown Zellerbach Corp. (Ind. Products Div.), Orzan "S": Tech. Bull. 532, 1956, 9 pp.

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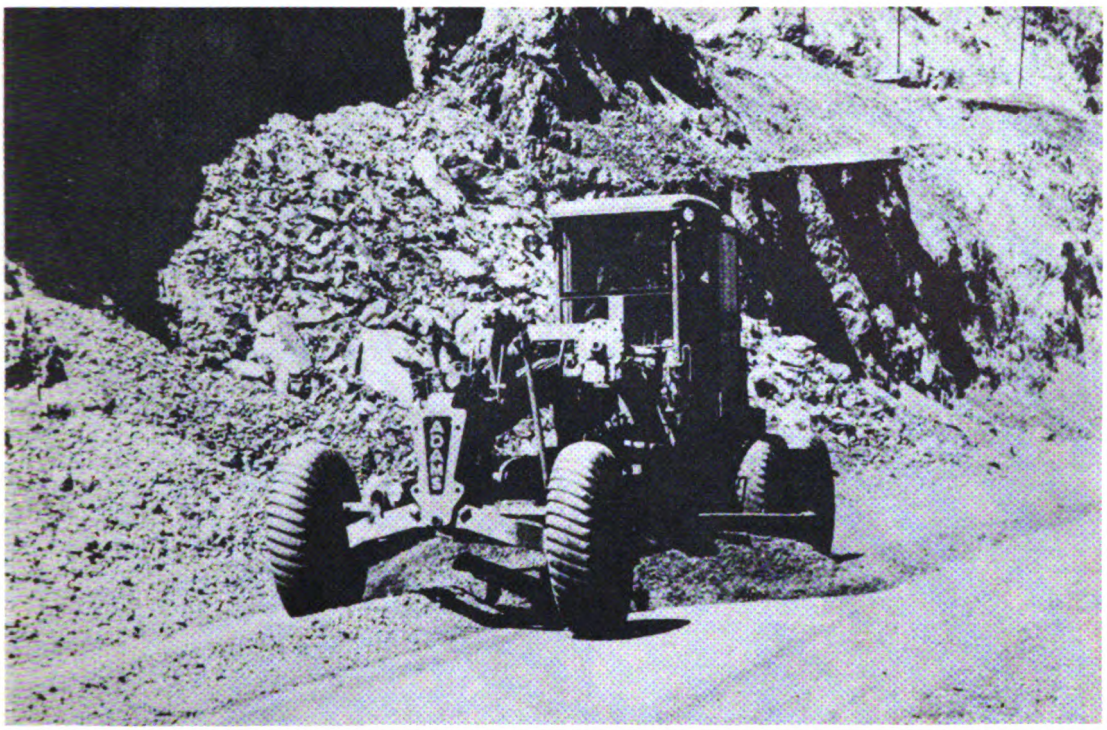

Figure 5. - First step in treating a dirt road is to eliminate potholes and corrugations by blading.

Figure 6. - Loose rock and gravel that will not pass through a 1-inch ring should be bladed off surface of road.

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Figure 7. - Before lignin sulfonate is added, aggregate should be a well-graded mixture of coarse and fine material.

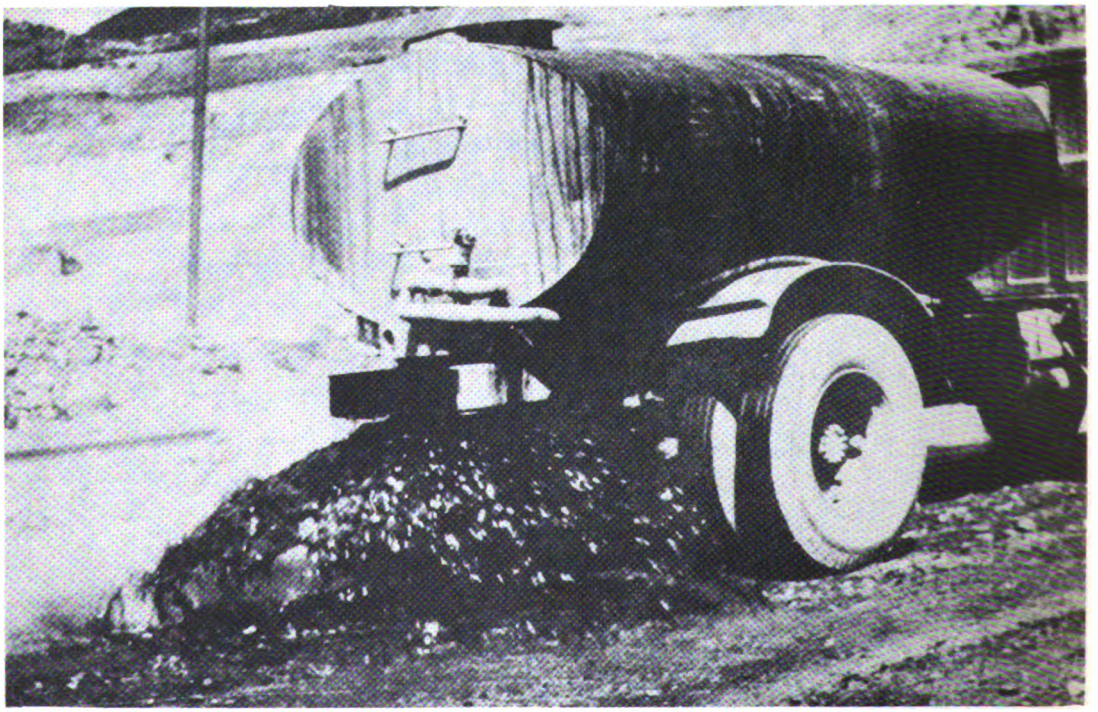

Figure 8. - Lignin sulfonate solids (10-25 percent) in water solution is sprayed repeatedly on prepared surface of road.

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2. Blade most of the loose material into windrows on both sides of the road to prevent runoff and to assure uniform penetration of lignin sulfonate solution into the subsurface.

3. After the windrows are formed, apply the liquid by spraying it on the road from a tank truck (fig. 8). The rate of application can be regulated either by valves, if the truck is equipped with a pump, or by adjusting the speed of the truck, if gravity-flow equipment is employed. Best wetting and dispersing action is obtained with a solution containing between 10 percent and 25 percent solid lignin sulfonate. Table 1 gives pertinent data on the subject. The concentration generally used depends on the moisture content of the soil. High concentrations are more practical for sand and very moist soils. It has been found that lignin sulfonate solution does not penetrate easily into dry, loose road aggregate consisting largely of dust and clay. It should be mixed thoroughly with the soil to obtain best results.

TABLE 1. - Lignin sulfonate (approx. specifications)

Solids in solution, percent	Specific gravity, 60°/60° F.	Weight of 1 gal., pounds	Lignin sulfonate solids per gal., pounds
8	1.05	8.75	0.70
10	1.055	8.79	.88
12	1.06	8.84	1.06
15	1.075	8.96	1.34
20	1.095	9.13	1.83
25	1.12	9.34	2.34
30	1.15	9.59	2.88
35	1.18	9.84	3.44
40	1.21	10.09	4.04
45	1.24	10.33	4.65
50	1.27	10.59	5.30
55	1.30	10.84	5.96

a. Spray one-third to one-half of the lignin sulfonate solution, specified for total treatment, between the windrows.

b. Blade windrows to center, spreading evenly.

c. Spray approximately one-third of total specified roadbinder on surface and blade or mechanically mix the solution and the aggregate with a grader or pulverizer. Save part of roadbinding solution for final top-dressing treatment.

4. The road is now ready for final forming. Since rapid surface drainage is important to lignin sulfonate-treated roads, the best type of crown is a modified A-type cross section with a uniform side slope of about one-half inch per foot from the center line to the edge of the road. The rounded crown commonly used on concrete pavement is not suitable for lignin sulfonate-treated roads as it allows pools of water to collect on the relatively flat center part of the road. Standing water can increase the plasticity of the road material to the point where traffic can cause potholes to develop. The importance of a proper A-type crown or equivalent cannot be stressed too much.

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5. After the final shaping and formation of the A-type crown, a top dressing of lignin sulfonate solution should be used to touch up any dry spots that might have been exposed during grading. This should be a relatively light spray, especially when the soil is wet, in order to avoid excess surface plasticity and runoff of valuable roadbinding material.

6. The final step is compaction. This is best done with a multiple-wheeled, rubber-tired roller, but very satisfactory results can be obtained by letting traffic do the compaction. Compaction must be done before the roadbinder dries, while the road material is still plastic. If it can be arranged to have some of the traffic use the center section of the road while the road is still damp, more uniform compaction will result. Such a surface will be smoother, harder, and longer lasting than would be the case if only the main traffic lanes were compacted.

7. The entire wearing surface of the road should be treated with lignin sulfonate, and windrows of gravel should be eliminated. The chemical should be distributed to the shoulders of the road, and all of the aggregate, except the oversize, should be bladed into the finished surface. It has been observed that high concentrations of dust are raised when traffic is forced onto untreated shoulders or onto unconsolidated aggregate along the edges of the road.

QUANTITIES

The quantity of lignin sulfonate to be used depends largely on the type of road desired as well as on the road material itself.

To create a more lasting road surface, it is desirable to stabilize it to a certain depth. Stabilization to a depth of 3 inches, using 1/2 to 1 percent of lignin sulfonate solids, by weight, in the soil is common practice. Satisfactory results have been obtained when 0.75 pound of lignin sulfonate solids per square yard of surface per inch of treated depth has been used. An occasional light surface application of the solution rebinds dust produced by abrasion and spillage.

SOILS BEST SUITED FOR LIGNIN SULFONATE ROADBINDER TREATMENT

An ideal road material contains good distribution of particle sizes, ranging from coarse aggregate to fine binding soil. The dispersing properties of lignin sulfonate permit compacting the ideal soil to a density almost as great as that of concrete. The roadbinder does not leach readily from these soils; they have a very small percentage of voids and when dry may have a compressive strength one-fourth that of concrete.

TABLE 2. - Ideal-soil material

Screen size	Percent passing
1-inch sieve	100
3/4-inch sieve	70-100
3/8-inch sieve	50- 80
No. 4 sieve	35- 65
No. 10 sieve	25- 50
No. 40 sieve	15- 35
No. 200 sieve	5- 20

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The ideal-soil specifications given in table 2 will give the best results, but good roads can be obtained with a wide variety of soils and particle-size distribution.

MAINTENANCE OF ROADS

A road with a good gradation of aggregate, properly treated with lignin sulfonate, requires very little maintenance. When soil treated with lignin sulfonate is the wearing mat, leaching from heavy rains may cause dust to reappear. If aggregate is insufficiently mixed with binding soil or water accumulates on an improperly built crown (the most frequent causes of trouble), potholes and raveling will result.

Ordinarily, road surfaces treated with lignin sulfonate should be maintained by patching rather than blading. Patching mixtures should be roughly of the same composition as the road surface. The bottom of the area that is to be patched, as well as the aggregate for the patch, should be well moistened with a solution of lignin sulfonate. The patching material should contain at least 1 percent of lignin sulfonate solids.

To repair raveling or extensive potholes and control excessively dusty conditions, the surface must be reworked. The best time is after a rain or after pretreatment with water or lignin sulfonate has softened the surface. The usual practice is to cut the road surface to the bottom of the potholes and treat the loose material as described in the section on Application. The goal in repairing the road is to get the proper mixture of soil particles with lignin sulfonate solution, good particle-size distribution, and a modified, A-type crown (or equivalent) that will shed water.

Excessive grading, especially when dry, should be avoided, because it loosens the bound surface and creates dust. Grade only when general shaping or repairing is needed.

Some road surfaces are very hard but still may be dusty. If enough loose muck to give the proper depth is not readily available, several light applications of lignin sulfonate solution (25 percent solids) will form a thin, hard crust that serves as a wearing surface and prevents dissemination of the dust. An interval of time should elapse between each application to allow moisture to evaporate. If traffic is permitted on the treated surface when it is tacky, the semidry lignin sulfonate will stick to the tires of the trucks. It is desirable to blade the road at least once between applications of the solution to move surface rocks, which might prevent complete coverage of the surface. As few loose rocks as possible should be left on the road, as they increase abrasion.

Thin applications of lignin sulfonate will not give service as good as that obtained when road aggregate is treated to a depth of 1 inch or more. Figure 9 shows the result of heavy-truck traffic on a road treated with a thin application of lignin sulfonate.

CONCLUSIONS

The purpose of improving haulage roads in open-pit mines is to provide better service in carrying heavy loads at higher speeds at a lower cost per ton-mile with a minimum dissemination of dust. Most road maintenance includes blading and sprinkling with water. Chemical treatments reduce the necessity of frequent blading and sprinkling. The method described here reduces the cost of maintenance (blading and

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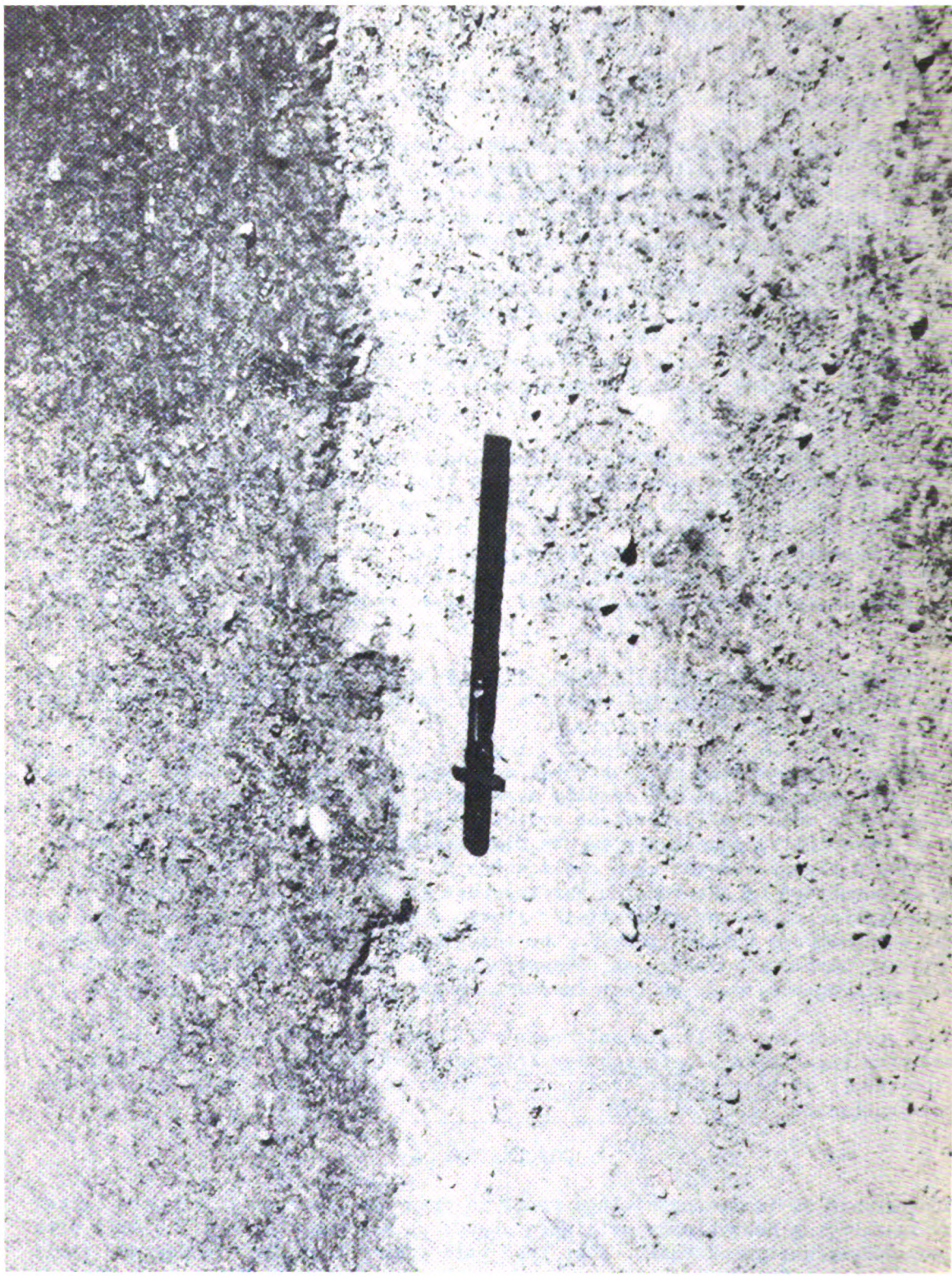

Figure 9. - Abrasion caused by heavy vehicles on surface of road treated with lignin sulfonate; 1/16-inch crust can be seen at edge of damaged area.

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sprinkling) and provides an improved surface. Lignin sulfonate is a waste product; it is relatively cheap and easy to apply; when properly applied, it has reduced the amount of blading needed to maintain a smooth surface. Dust normally raised by heavy truck-traffic is kept below objectionable limits without using water. Figure 10 shows a truck on an untreated hill, and a high concentration of dust can be seen following the truck. Figure 11 shows the same truck on the treated section of the road. The cloud of dust in the background stopped abruptly at the junction of the treated and the untreated sections. Figure 11 was photographed on the same bench shown in figure 1.

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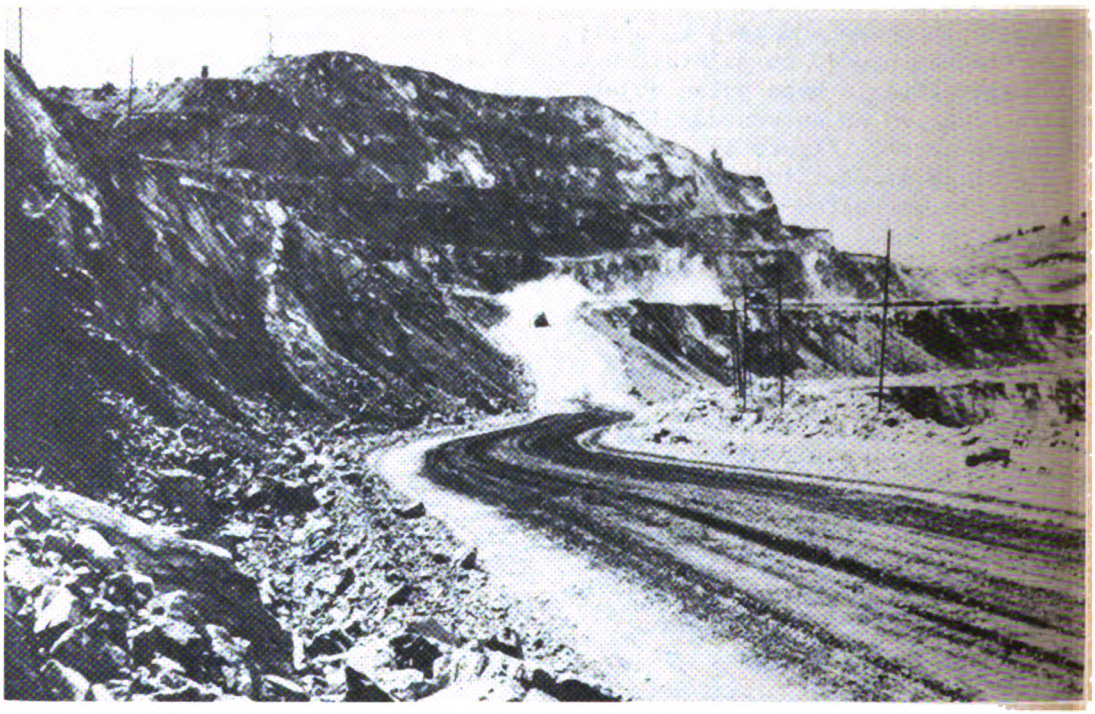

Figure 10. - Truck on untreated section of mine road, part of which has been treated with lignin sulfonate. Note dust cloud.

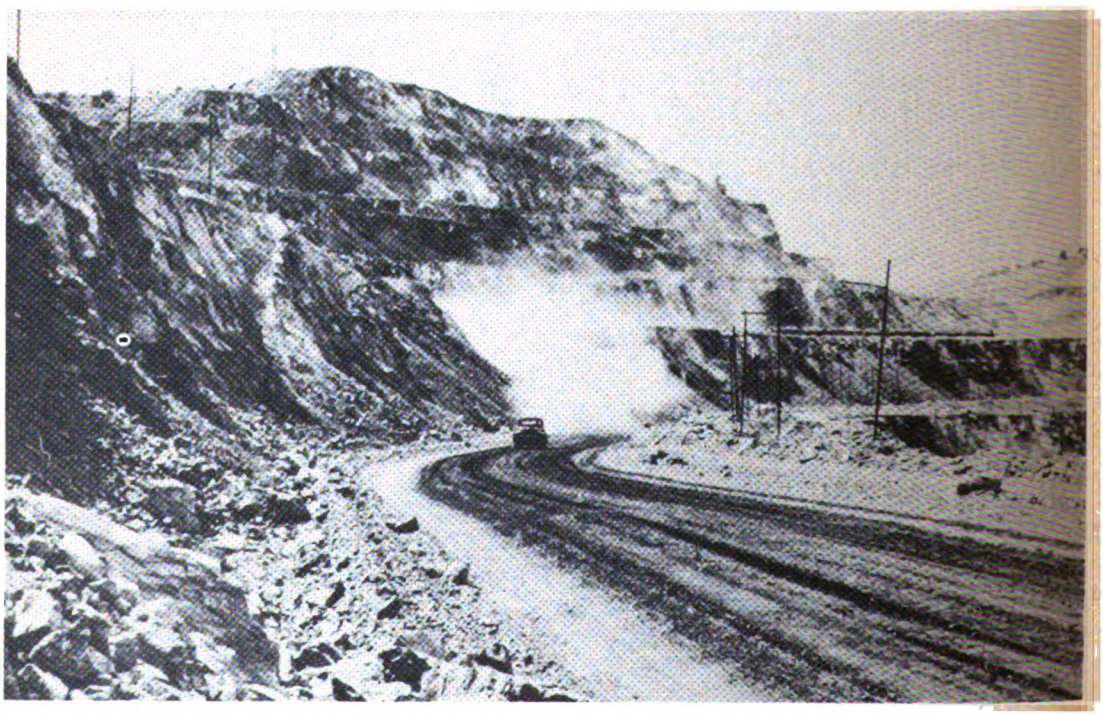

Figure 11. - Note that dust cloud stopped abruptly when truck seen in figure 10 reached part of road treated with lignin sulfonate.

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